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Exploring the Lane Changing Duration Time on U-turn Facility

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Abstract: Driver's behaviour while making a Lane Changing (LC) in the shortest time could lead to an accident. At a U-turn facility, drivers need to make decisions to perform a U-turn and merge to the major road or the target lane and apply Mandatory LC type. Thus, objective of this study aims to examine the LC behaviour among drivers at U-turn facility by measuring the LC duration time (in seconds) of the vehicles from U-turn facility to the target lane (major road). The LC duration time was collected through a manual observation by using a mobile application and video camera. The observation was conducted in two weekdays for three peak hours (morning, afternoon, and evening). The descriptive statistics was used to analyze the data for day 1(N=364) and day 2(N=344) by using a Microsoft Excel software in order to achieve the study objectives. The results show that the motorcycles have the shortest mean in LC duration time compare with other types of vehicles at U-turn facility. In conclusion, the LC duration time on day 2 yields the same result as day 1, namely that motorcycles have the shortest mean of LC duration since they are small and light when making a LC maneuver. In contrast to other vehicle categories, heavy trucks had the highest mean LC duration because they carried heavy loads and needed more time to make a LC maneuver compared to other vehicle types. Therefore, LC are able to identify the characteristics of drivers' behaviour while making lane changing at U-turn facility to the target lane.

Keywords: Lane Changing, U-Turn Facility, Duration Time, Selangor

1. Introduction

Road accident is one among the key causes of death and injuries in Malaysia. As a developing country, the road network are major facilities because it consists of combination of road network and highways. The structure and combination of road is transportation facilities because it connected one place to another place in daily life. Road injuries and fatal are growing concern in Malaysia due to the increment number in road death [1]. U-turn can be defined as a turning of the vehicle or performing a 180 degree of rotation to head to the opposite direction from original road [2]. The factors that could contribute to road accident are human error, traffic vehicle, road condition and surrounding environment

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[3]. The U-turning movement at U-turn facilities involve converging, weaving, diverging and merging for the vehicle to enter the lane. Therefore, The U-turning movement at U-turn facilities involve converging, weaving, diverging and merging for the vehicle to enter the lane [1]. Therefore, the movement may lead to traffic and accident fatal. Other than that, weaving or lane changing at U-turn facility, emphasized that weaving is a process that involve in lane changing (LC). The weaving occurs when drivers desire to position their vehicle in a carriageway lane.

The aim of this research is to measure the LC duration time (in seconds) of the vehicles from U-turn facility to the target lane. The mean and standard deviation is used to determine the relationship between lane changing duration time of the drivers at U-turn facility. The LC duration time is collected through a manual observation by using a mobile phone application and video camera.

2. Lane Changing (LC)

The function of U-turn facility is involving a LC. A LC is a process of changing a new lane without any disruption on the road [4]. The process of LC has several different types which are weaving, merging and diverging process. LC is a process to determine which is the best lane to drive without having any interruption on the road and also occurred when a driver wants to enter the target lane or preferred lane of destination [1]. LC also can be defined as a driving maneuver that moves a vehicle from one lane to another where both lanes have the same direction of travel or the driver intention to move in lateral direction of the vehicles [1].

LC will occurs based on several factors such as entering the roadway, preparing to exit the roadway, to merging, slowing the lead vehicle and change in the number of lanes [1]. During LC, some interactions will occur with with surrounding environment conditions or surrounding vehicle that can affect the acceleration or deceleration of the vehicle during LC and the behaviour of the drivers [1,5]. The LC duration time can influence on traffic flow and safety, as well as driving behaviour. LC duration time is longer when the vehicles take a longer time in order to avoid a dangerous situation [6]. The vehicle changes lane from the original lane to the target lane can affect the drop of shockwaves capacity that are generated from both lanes [1]. To avoid collision to occur, the vehicle from the U-turn Road must be careful and precautious when to enter the enter the main lane. However, the process of LC can cause a weaving, merging and diverging processes that will vary according to the various road environment and the traffic conditions.

2. Materials and Methods

The data that has been collected was analysed by using a Microsoft Excel software. The data were analysed to determine the mean and standard deviation in order to determine the LC duration time of vehicles from U-turn facility to the target lane. The total number of vehicles observed in day 1 was 353(N=364) and total number of vehicles observed in day 2 was 344 (N=344).

2.1 Materials

The data of LC duration time of the drivers at U-turn facility were observed and the data were collected for two weekdays on Monday (5th April 2021) and on Friday (9th April 2021) during three peak hours per day (morning, afternoon and evening with one hour each period). The types of vehicles category that involved in this study are motorcycles, cars, medium trucks, heavy trucks and buses.

2.2 Methods

The method for this study before collected the data was to identify the objectives of the study. Then, determine the site location that have a U-turn facility. Then, the LC duration time was observed at the location. During the collection of data, ensure that the location for the observation and camera set up should be placed at the side of the road. After getting the data from observation, the data was arranged

and extract in the Microsoft Excel to screening and run the data. The value of mean and standard deviation for each type of vehicles has a different value.

2.3 Study location

The study location was at Selayang Baru area in Selangor state, in which it is located at Jalan Sungai Tua with latitude and longitude of 3.250890, 101.675178 as shown in Figure 1.1. In this area, a midblock U-turn type is available. The data collection was done by a direct observation and by using a video recording as shown in Figure 1.2. The U-turn facility is a main route for users who travelled from Batu Caves to Sungai Tua. From the video recording, we can take a data the data from the video such as the time taken and types of vehicles that making a LC at U-turn facility.

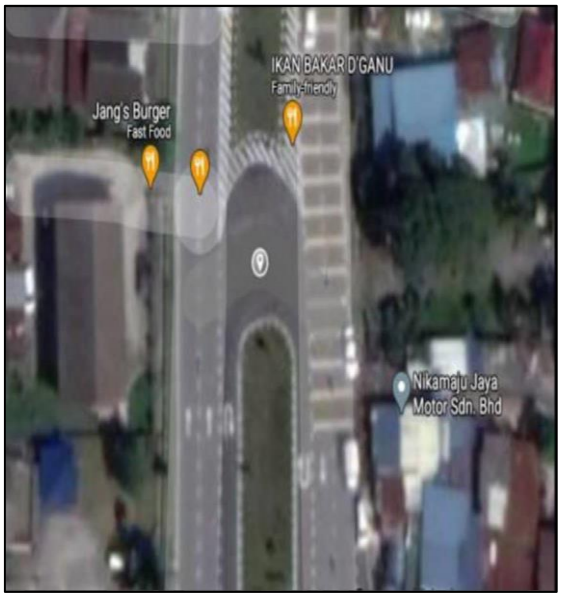

Figure 1.1: Midblock U-turn facilities at Jalan Sungai Tua

Figure 1.2: The video recording at U-turn facility for the data collection

2.4 Equations

This data has been collected are the time duration (in seconds) of the vehicles to make a LC at U-turn facility by using a primary data that are derived directly from an observation. As the vehicles' tyres touch the dotted line in between accelerating lane and the target lane, the LC duration time is recorded. The LC duration time consists of two parameters which is the time interval between elapsed time for the vehicles start to make a LC and the time taken of the vehicles full enter the target lane [6]. Then, by using a timer, time is taken to take the initial readings of the vehicles in order to execute LC, and the stopwatch is stopped when the entire body of the vehicles is fully in target lane. The LC duration time was calculated by using Eq. 1[6] below.

$$\text{LC duration time, t} = t_{fe} - t_{fs} \; Eq.1$$

Where:

t_{fe} = time taken of elapsed time for the vehicles start to make a LC

t_{fs} = time taken of the vehicles fully enter the target lane.

3. Results and Discussion

The results in Table 1 and Table 2 show the descriptive statistic of LC duration time of the vehicles from U-turn facility to the target lane for two days of the collected data in three peak hours which is in the morning, afternoon and evening for the different types of vehicles.

Table 1: Descriptive statistic of LC duration time (in seconds) of vehicles from U-turn facility to the target lane in day 1 on Monday (5th April 2021)

Day 1							
Items	**Type of Vehicles**	**Morning**		**Afternoon**		**Evening**	
		Mean	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
1.	Motorcycles	2.2952	0.5158	2.6076	0.6987	2.5357	0.8515
2.	Cars	3.7598	1.4408	4.3526	1.7812	3.5941	1.6741
3.	Medium Trucks	3.5200	0.0000	5.1800	2.7924	4.5130	1.1278
4.	Heavy Trucks	5.2033	1.8723	0.0000	0.0000	7.6400	2.7372
5.	Buses	0.0000	0.0000	6.91000	0.0000	6.9400	0.0000

Table 1 displays the mean and standard deviation for three peak hours on day 1 based on the LC duration time (in seconds) of different types of vehicles from U-turn to target lane in the morning, afternoon, and evening. As can be seen in the table above, different types of vehicles produce varying LC duration values in terms of mean and standard deviation. For the motorcycles, the highest mean for motorcycles was 2.6076 seconds with a standard deviation of 0.6987 seconds in the afternoon, compared to the lowest mean in the evening. Next, the highest mean for cars was about 4.3526 seconds

with a standard deviation of 1.781 seconds in the afternoon, followed by the morning and evening. Moreover, the highest mean for medium trucks was 5.1800 seconds in the afternoon, with a standard deviation of 2.7924 seconds, and the lowest mean was in the morning. Furthermore, the highest mean value for heavy vehicles was in the evening, with a mean of 7.6400 seconds and a standard deviation of 2.7372 seconds. However, since none of the heavy vehicles used the U-turn facility in the afternoon, thus it has the lowest in mean and standard deviation. Finally, the buses with the highest mean was in the evening with 6.9400 seconds and the lowest mean was in the morning and evening due to a no presence of buses used the U-turn facility at that time.

Table 2: Descriptive statistic of LC duration time (in seconds) of vehicles from U-turn facility to the target lane in day 2 on Friday (9th April 2021)

Day 2							
Items	**Type of Vehicles**	**Morning**		**Afternoon**		**Evening**	
		Mean	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
1.	Motorcycles	3.4257	1.2711	3.3135	1.2296	2.4400	0.6087
2.	Cars	5.0108	3.0879	4.3104	1.6423	2.9273	0.7714
3.	Medium Trucks	11.7840	6.7303	5.7100	2.3843	3.3333	1.3408
4.	Heavy Trucks	22.9200	0.0000	0.0000	0.0000	6.1533	2.5966
5.	Buses	0.0000	0.0000	0.0000	0.0000	7.4900	2.1637

Table 2 shows the data on day 2 by obtained the LC duration time (in seconds) of different types of vehicles in the morning, afternoon, and evening from the U-turn facility to the target lane. From the data, different types of vehicles can be identified and calculated of their mean and standard deviation of LC duration values. In comparison to the afternoon and evening, for the motorcycles, the highest mean was 3.4257 seconds with a standard deviation of 1.2711 seconds in the morning. This is may be due to of the location of the U-turn facility which is near to housing areas and schools, thus, the number of motorcycles using the U-turn facility increased in the morning, which is the busiest period for workers for going to work. Furthermore, for cars, the highest mean was in the morning with 5.0108 seconds and a standard deviation of 3.0879 seconds compared with in the afternoon and evening. In addition, the morning had the highest mean for medium trucks with a mean of 11.784 seconds and a standard deviation of 6.7303 seconds. Hence, the lowest mean was 3.333 seconds in the evening, with a standard deviation of 1.3408 seconds. Furthermore, the highest mean for heavy vehicles was 22.9200 seconds with a standard deviation of 0.00 seconds in the morning contrasted to the lowest mean and standard deviation of 0.00 seconds in the afternoon because none of heavy trucks used the U-turn facility at that time. Finally, for buses, the highest mean and standard deviation in the evening, with 7.4900 seconds and 2.1637 seconds respectively. Meanwhile, because none of bus used the U-turn facility on day 2, the lowest mean was 0.00 seconds, and the standard deviation was 0.00 seconds in the morning and afternoon.

3.1 Discussion

The LC duration time of vehicles from U-turn facility to the target lane in day 1 and day 2 are quite similar which is, in day 1, for the motorcycles, cars and medium trucks has the highest mean and

standard deviation in the afternoon. For heavy trucks, has the highest mean in the evening. For day 2, the motorcycles, cars, medium trucks and heavy trucks has the highest mean and standard deviation in the morning. Meanwhile for buses, has the highest mean and standard deviation in the evening for day 1 and day 2. Therefore, this study can conclude that, the LC duration time is different for each types of vehicle and also different in each observation in the morning, afternoon and evening. This is because, it depends on the traffic volume on major road either many of the vehicles used the U-turn facility on day 1 and day 2 and also it depends on type of vehicles. Moreover, the heavy vehicles such as heavy trucks or buses drive in a slower speed and have higher LC duration time compared to other vehicle types. However, the heavy vehicles require more time to execute the LC manoeuvre. Meanwhile, the car, motorcycles or are mostly to increasing their speed until they become close to the average speed in the target lane and that cause the LC duration time to become shorter compare with heavy vehicles.

The difference between the mean and standard deviation might be due to the drivers' behaviour while making a LC at U-turn facility. While making a LC at U-turn, the drivers gap acceptance behaviour can be influenced by personality traits such as duration time or aggressiveness behaviour. Study by [7] found that, LC at U-turn can be successful and safe if there has a gap of sufficient size for the driver to enter the target lane [8,9] and the drivers gap acceptance behaviour can be influenced by personality traits such as aggressiveness [10]. According to [11], the best time for the vehicle to begins for making a LC are when the drivers are fully to scanning the environment or vehicles that come from the target lane.

4. Conclusion

In conclusion among the four types of vehicles, the highest mean and standard deviation in day 1 and day 2 of the LC duration time are evaluated. The dominant of the LC duration time in day 1 for the motorcycles that has the highest mean with 2.6076 seconds with standard deviation of 0.6987 seconds was obtained in the afternoon. In addition, in day 2, was in the morning with a mean of 3.4257 seconds with a standard deviation of 1.2711 seconds. Then, for the cars, in day 1, the highest mean was in the morning with 4.3526 seconds and standard deviation of 1.7812 seconds. Meanwhile in day 2, the highest mean was in the morning with 5.0108 seconds and standard deviation of 3.0879 seconds. Moreover, for the medium trucks, the highest mean was 5.1800 seconds with standard deviation of 2.7924 seconds in the afternoon. In addition, in day 2 was in the morning with a mean of 11.784 seconds and standard deviation of 6.7303 seconds. For the heavy trucks, the highest mean value was in the evening with the mean 7.6400 seconds and standard deviation of 2.7372 seconds. Meanwhile in day 2, was in the morning with 22.9200 seconds and standard deviation of 0.00 seconds. Lastly, for the buses, the highest mean of LC duration time in the evening with 6.9400 seconds ad standard deviation of 0.000 seconds. Meanwhile in day 2, the highest mean in the evening with 7.4900 second and standard deviation of 2.1637 seconds. From previous research [6] LC duration of the motorcycles has more than 90% of the riders have a high level of aggressiveness in their LC driving behaviour. Meaning that the LC duration time of motorcyclists are the shortest, as found in this study. Meanwhile, based on [6,12], heavy vehicles' drivers tend to drive in a safe aggressive and be more cautious and careful while making a LC manoeuvre at U-turn. Meaning that the LC duration time of heavy vehicles' drivers are the longest, as found in this study. Some recommendations for this study is that an authority should make a marking line clearly that may include the symbols for the drivers to slowing the vehicles while they want to make a LC at a U-turn facility. Second, conducting a campaign of awareness about the statistic of death causes by the road accidents through an advertisement can be done so that the drivers and riders will be more careful while driving especially during a LC manoeuvre.

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